

DATE: January 5, 2004

FILE: 35-21

TO: Region Engineers
Region Delivery Engineers
Region Development Engineers
TSC Managers
Resident/Project Engineers
Region Construction Engineers
Region Traffic and Safety Engineers
Region Maintenance Engineers

FROM: Larry E. Tibbits
Chief Operations Engineer

John C. Friend
Engineer of Delivery

SUBJECT: Bureau of Highway Instructional Memorandum 2004-01
Light Emitting Diode (LED) Traffic and Pedestrian Signal Installations

In an effort to reduce long term maintenance and power consumption costs associated with traffic and pedestrian signals, on October 3, 2003, the Engineering Operations Committee approved the Special Provisions and Standard Details for Light Emitting Diode (LED) signals. The Special Provisions and Standard Details (attached) specify that LED lenses are only to be used in the green and red indications and incandescent bulbs for the yellow indication. This mix of incandescent and LED technology is necessary to comply with current ITE light emission requirements.

The department's implementation plan is to use these devices on new installations or modernizations (including contract locations and those completed under the Transportation Work Authorization process). This allows utilization of Federal funds and minimizes high equipment costs to both the department and participating local agencies. As each installation is completed, new cost agreements reflecting the power consumption savings will be developed. It is anticipated the modernization contracts beginning in the spring of 2004 will be some of the first locations to be converted to the LED signals.

These devices have a manufacturer's warranty of five years and should not require re-lamping on the traditional yearly cycle. By the time the new LED equipment requires re-lamping, the maintenance budget will be adjusted to accommodate the newer technology.

While this technology has been used by other state transportation departments and several Michigan local agencies, it is new to MDOT and we will monitor its use and effectiveness. The department will also evaluate the developing yellow indication LED lenses to determine compliance with ITE light emission requirements. If a yellow LED lens which meets the requirements is developed, the special provision and standard details will be modified to include its use. If any issues should develop or you have any questions, please contact the Lansing Traffic Signals Unit at 517-373-2324.

Chief Operations Officer

Engineer of Delivery

BOH-DEL:T&S:PJC:nw

Subject Index: Traffic Control

Attachment

cc: J. Culp, Traffic and Safety Support Area
C & T Support Area Staff
M. DeLong, Real Estate Support Area
M. VanPortfleet, Design Support Area
C. Roberts, Maintenance Support Area
B. O'Brien, C & T Support Area
J. Polasek
S. El Ahmad, OEO
C. Rademacher
V. Blaxton
G. Moore
K. Reincke

T. Fudaly, FHWA
MRBA
MAPA
MCPA
MCA
MAA
AUC
CRAM
MRPA
ACEC
MPA

MICHIGAN
DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION
FOR
LIGHTING EMITTING DIODE (LED) VEHICLE TRAFFIC SIGNALS

T&S:WPS

1 of 5

C&T:APPR:JKG:BRZ:08-19-03

a. Description. These specifications cover the utilization of Light Emitting Diode (LED) Vehicle Traffic Signals in either a new traffic signal installation or as a retrofit unit capable of replacing the optical unit of existing vehicular traffic signal sections meeting the Interim Institute of Transportation Engineers (ITE) for Vehicle Traffic Control Signal Heads (VTC SH) Part 2: Light Emitting Diode (LED) Vehicle Traffic Signal Modules dated July 1998. Section 820 (Traffic Signals) and Section 921 (Permanent Traffic Signal Materials) of the MDOT 2003 Standard Specifications for Construction shall be used for the Vehicle Traffic Signal and Mounting Assemblies and Construction requirements with the Optical Unit modified for use of LED signal modules.

b. General Requirements. LED traffic signal modules shall only be used for the Green and Red ball and arrow lens. Reference to LED module in this special provision will pertain only to those specific signal indications. The Yellow ball and arrow indications will continue to use the current incandescent optical units as specified in the MDOT 2003 Standard Specifications for Construction.

The LED signal shall achieve the minimum intensity requirements of the ITE photometric test criteria as described in the Interim ITE LED purchase specifications of the Vehicle Traffic Control Signal Heads (VTC SH) Part 2: Light Emitting Diode (LED) Vehicle Traffic Signal Modules, dated July 1998. If required, the manufacturer shall provide independent lab test results certifying the LEDs meet ITE specifications for LED signals.

c. Physical and Mechanical Requirements:

1. General:

- A. LED traffic signal modules shall not require special tools for installation. The LED modules shall fit into existing Eagle Signal type (or approved equal) traffic signal housings without modification of the signal housing. Installation of the LED module shall only require removal of the existing lamp, socket assembly, gasket, and reflector. The LED module shall be installed in the existing door and connected to the existing terminal block. Screw-in type products are not allowed for vehicle signals.
- B. Each LED module shall be a self-contained unit consisting of a lens, color coded leads with pre-insulated spade lugs, LED assembly, power supply, and a one-piece neoprene gasket. When retrofitting into an existing traffic signal housing, the LED module shall be provided in a new signal door and visor assembly.
- C. The assembly and manufacturer's process for the LED assembly shall be designed to assure all internal LED and electronic components are adequately supported to

- withstand mechanical shock and vibration. The LED vehicle signal manufacturer shall be ISO 9001 certified.
- D. The LED signal module shall be protected against dust and moisture intrusion per the requirements of NEMA Standard 250, 1991 for Type 4 enclosures to protect all internal LED, electronic, and electrical components.
 - E. The LED signal module lens shall be made from ultraviolet stabilized polycarbonate. The Red and Green lenses shall be color tinted Red or Green. The lens shall require no special tools for replacement.
 - F. The external lens surface for all vehicle signals shall be smooth, with no raised features, to minimize the collection of dirt, diesel smoke, and other particulate contaminants, and to facilitate periodic cleaning.
 - G. Each signal module shall be identified with the manufacturer's name, model number, serial number on the outside of the unit, related voltage, and power consumption. The identification tag shall be visible without disassembly of the signal module.
 - H. Each LED signal module shall have a prominent and permanent vertical indication for proper orientation inside a traffic signal housing.
 - I. The Red and Green LED module shall consist of 18 or less, high flux LEDs mounted on a partially embedded and integral metal layer in the LED module. The lens assembly shall consist of an inner lens which is sealed to the lamp housing and serves to collimate the light emitted by the high flux LEDs and an outer lens which serves to focus the light to meet ITE intensity and distribution standards.
 - J. The arrow LEDs shall be mounted and soldered to a printed circuit board. The LED signal shall be watertight when properly installed in a traffic signal housing. The LED signal module(s) shall utilize the same mounting hardware used to secure an incandescent lens and gasket assembly, and shall only require a screwdriver or standard installation tool to complete the mounting. The LED signal module assembly shall weight less than 5 pounds.
2. Aluminum Vehicular Traffic Signals and Mounting Assemblies:
- A. MDOT Special Provision for Aluminum Vehicular Traffic Signals and Mounting Assemblies approved 3/11/2002 shall be used for meeting all requirements for signal faces, mounting assemblies, paint, and color with the optical unit modified for use of LED signal modules.
 - B. LED traffic signal modules shall not require special installation tools. The LED modules shall fit into existing Eagle Signal type (or approved equal) traffic signal housings without modification of the signal housing. Installation of the LED module shall only require removal of the existing lamp, socket assembly, gasket, and reflector. The LED module shall be installed in the existing door and connected to the existing terminal block. Screw-in type products are not allowed for vehicle signals.

- C. Each LED module shall be a self-contained unit consisting of a lens, color coated leads with pre-insulated spade lugs, LED assembly, power supply, and a one-piece neoprene gasket.

d. Electrical:

1. General: Minimum performance requirement for LED signals include:

- A. The LED signal module shall operate from a 60 Hz line frequency and over a voltage range of 80-135 volts. A change of luminous intensity of no more than ± 10 percent shall be allowed over the voltage range.
- B. The LED signal module shall operate over a temperature range of -40 degrees F (-40 degrees C) to 165 degrees F (74 degrees C).
- C. Each LED signal module shall be provided with two color coded No. 18 gauge, 36 inch long, 600v, jacketed wires, conforming to the National Electrical Code, rated for service at + 221 degrees F (+105 degrees C). The wire leads shall be provided with pre-insulated spade terminals for connection to existing traffic signal terminal blocks.
- D. The LED signal module shall include voltage surge protection to withstand high-repetition noise transients and low-repetition, high-energy transients as stated in section 2.1.6 of the NEMA Standard TS-2, 1992.
- E. The LED circuitry shall prevent flicker at less than 100 Hz over the voltage range specified in section 5.2.1.
- F. The LED signal and associated on-board circuitry must meet Federal Communications Commission (FCC) Title 47, Sub Part B, Section 15 regulations concerning the emission of electronic noise.
- G. Power factor shall be 90 percent or greater, at nominal rated voltage, at 77 degrees F (25 degrees C), after 60 minutes of operation. Total harmonic distortion (THD) shall be less than 20 percent at rated voltage, at 77 degrees F (25 degrees C).
- H. The LEDs shall be connected in series parallel strings. For LED ball type signals, the failure of a signal LED shall cause loss of light from only that LED. No loss of light output from the complete module assembly shall occur as a result of a single LED failure in a LED ball lamp.
- I. The LED signal module shall be operationally compatible with currently used controller assemblies (solid state load switches, flashers, and conflict monitors) with the exception of the dimming function.
- J. The LED signal and associated on-board circuitry must meet Federal Communications Commission (FCC) Title 47, Sub Part B, Section 1r regulations concerning electronic noise emission.

2. Power Consumption and Operational Range:

- A. Green ball LED traffic signal modules shall consume no more than a nominal 12 and 15 watts for the 8-inch and 12-inch lamps respectively, at 120 VAC, at 77 degrees F (25 degrees C). Maximum power consumption shall not exceed 18 and 20 watts respectively, at 120 VAC, at 165 degrees F (74 degrees C). Green ball LEDs shall not illuminate for input voltages below 35 volts and shall illuminate for all input voltages higher than 45 volts (and be regulated above 80 volts).
- B. Red ball LED traffic signal modules shall consume no more than a nominal 7 and 10.5 watts for the 8-inch and 12-inch respectively, at 120 VAC, at 77 degrees F (25 degrees C). Maximum power consumption shall not exceed 13 and 17 watts respectively, at 120 VAC, at 165 degrees F (74 degrees C).
- C. Green arrow LEDs shall consume no more than a nominal 6.7 watts for 12-inch indications. Red arrow LEDs shall consume no more than a nominal 7.4 watts for 12-inch indications. Maximum power consumption shall not exceed 10 watts for the Green arrow and 11 watts for the Red arrow. The LED arrow modules shall be wired so a catastrophic failure of one LED will not result in the loss of more than 5 percent of the total LED signal illumination.
- D. Red and Green ball LED traffic signal modules and Red and Green arrow LED traffic signal modules shall meet the minimum intensity requirements while operating over the temperature range of -40 degrees F (-40 degrees C) to 165 degrees F (74 degrees C) for a period of 5 years.
- E. The Red LEDs shall utilize exclusively Al In GaP technology, either AS (Absorbing Substrate) to TS (Transparent Substrate), and shall not exhibit degradation of more than 30 percent of their initial light intensity following accelerated life testing [operating at 185 degrees F (85 degrees C) and 85 percent humidity, for 1000 hours]. Al Ga As technology is not acceptable.
- F. The Green LEDs shall utilize Indium gallium nitride technology. Green LED traffic signal modules shall not be illuminated when the applied voltage is less than 35 VAC. They shall be illuminated (unregulated) when the applied voltage is 45 VAC to 80 VAC. Their illumination shall be in compliance with the July 1998 ITE CTCSH, Part II, when applied voltage is between 80 VAC and 135 VAC.
- G. The LED modules shall be operationally compatible with NEMA TS-1 and NEMA TS-2 conflict monitoring parameters.

e. Photometric Requirements:

- 1. The minimum initial luminous intensity values for the LED traffic signal module shall be as defined in Section 4 of the ITE Interim LED Purchase Specifications, Part 2: Light Emitting Diodes (LED) Vehicle Traffic Signal Modules dated July 1998.
- 2. The Red and Green LED traffic signal module shall meet the minimum intensity requirements while operating over the temperature range of -40 degrees C (-40 degrees F) to 74 degrees C (+165 degrees F) for a period of 5 years.

3. The measured chromaticity coordinates of LED traffic signal modules shall be between 500 nm and 650 nm and conform to the requirements of Section 8.04 and figure 1 of the VTCSH Standard.
4. Test data to verify the performance for Red and Green ball signals as meeting the July 1998 ITE VTCSH, Part II intensity requirements at 165 degrees F (74 degrees C) shall be supplied by a certified independent test lab.

f. Warranty. All LED traffic signal modules supplied shall be warranted for 5 years from the date of delivery against manufacturing defects. LED modules shall be performance warranted for 5 years per Section 4.1.1. of the Interim LED Purchase Specification of ITE, dated July 1998.

g. Measurement and Payment. The completed work as measured for the following contract item (pay item) includes installation of LED traffic signal modules for the Green and Red ball and/or arrow lenses and removal of the existing lamp, socket assembly gasket, reflector and door assembly (when appropriate), hardware, fittings, conduit, riser(s), grounding and ground rod(s), cable, and such other material to complete the work. The LED modules shall be provided installed in an Eagle Signal type (or approved equal) polycarbonate door and visor assembly.

Contract Item (Pay Item)	Pay Unit
TS, ___ Way ___ Mtd (LED)	Each
TS, ___ Way ___ Mtd (LED) Retrofit Assembly	Each
TS, 4 th Level ___ (LED)	Each
TS, 4 th Level ___ (LED) Retrofit Assembly	Each

MICHIGAN
DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION
FOR
LIGHT EMITTING DIODE (LED) PEDESTRIAN TRAFFIC SIGNALS

T&S:WPS

1 of 5

C&T:APPR:JAR:JKG:07-24-03

a. Description. Furnish and install Light Emitting Diode (LED) Pedestrian Traffic Signals in either a new traffic signal installation or as a retrofit unit capable of replacing existing pedestrian traffic signal assemblies. The LED Modules must meet the Interim Institute of Transportation Engineers (ITE) LED Purchase Specifications of the Pedestrian Traffic Control Signal Indications (PTCSI) Part 2: Light Emitting Diode (LED) Pedestrian Traffic Signal Modules, dated February 2003; hereafter, referred to as LED Purchase Specifications. Sections 820 and 921 of the Standard Specifications for Construction shall be used with appropriate modifications to Housing, Visors and Mounting Assemblies to accommodate LED pedestrian signal modules.

b. Materials.

1. General Requirements: LED pedestrian signal modules shall be capable of displaying either the ITE specified symbolic full icon "hand" or "walking person" using a one-piece section which includes a nominal message-bearing surface size of 12 inches x 12 inches.

The LED signal shall achieve the minimum intensity requirements of the ITE photometric test criteria as described in the LED Purchase Specifications. If required, the manufacturer shall provide independent lab test results certifying the LEDs meet the ITE specification for LED signals.

2. Physical and Mechanical Requirements:

A. General:

- (1) LED pedestrian signal modules shall not require special tools for installation or replacement.
- (2) Each LED module shall be a self-contained unit.
- (3) The assembly and manufacturer's process for the LED assembly shall be designed to assure all internal LED and electronic components are adequately supported to withstand mechanical shock and vibration. The LED vehicle signal manufacturer shall be ISO 9001 certified.
- (4) The LED signal module shall be protected against dust and moisture intrusion per the requirements of MIL-810F procedure I Rain and Blowing Rain to protect all internal LED, electronic, and electrical components. The test is to be conducted on a stand-alone unit.

- (5) The LED signal module lens shall be made from ultraviolet stabilized polycarbonate. The lens shall be tinted or shall use transparency film or materials with similar characteristics. If requested, on a non-fused polymeric lens a surface coating or a film shall be used to provide front surface abrasion resistance.
- (6) The external lens surface for all pedestrian signals shall be smooth, with no raised features, to minimize the collection of dirt, soil, diesel smoke, and other particulate contaminants, and to facilitate periodic cleaning.
- (7) Each LED signal module shall be identified with the manufacturer's name, model number, serial number on the outside of the unit, rated voltage, and power consumption. The identification tag shall be visible without disassembly of the signal module.
- (8) Each LED signal module shall have a prominent and permanent vertical indication for proper orientation inside a pedestrian signal housing.

B. LED Assembly:

- (1) The LED Assembly shall consist of an LED array mounted to a printed circuit board and sealed in a polycarbonate cover assembly. The cover assembly shall be secured to a 12-inch polycarbonate clear matte signal lens. The assembly shall have 18-inch, 18 A.W.G. color-coded leads with pre-insulated spade terminals provided for attachment to the signal terminal block.
- (2) The retrofit assembly shall require removal of the existing housing and mounting assembly and reconfiguration of the mounting brackets to accommodate the one-piece LED pedestrian signal housing.
- (3) Retrofit replacement modules shall fit into existing signal housings built for the PTCSI sizes of the "hand" and "walking person" icon pedestrian Standard without modification to the housing.
- (4) Screw in type products will not be allowed for pedestrian signals.

C. LED Array:

- (1) The LED array shall consist of a highly visible full icon symbol of the "hand" and "walking person". The "hand" symbol shall be approximately 9 inches tall and consist of approximately 70 Portland Orange LEDs. The "walking person" shall be approximately 9 inches tall and consist of approximately 70 lunar white LEDs. All wires shall be #18 A.W.G. or larger with thermoplastic insulation.
- (2) The orange LEDs shall be Al In GaP, 605nm (Portland Orange, T 1 3/4). The white LED shall utilize Indium Gallium Nitride technology (In Ga N, T 1 3/4).

D. Housing:

- (1) The housing of each section shall be a one (1) piece black polycarbonate resin material with front, sides, top, and bottom integrally molded. The housing shall be of substantial thickness, with a minimum thickness of 3/32 inch, and shall be ribbed to produce the strongest possible assembly, consistent with being lightweight. Two sets of internal bosses shall be provided in the section for horizontal mounting of terminal strip facilities. The terminal blocks shall be attached to bosses with two self-tapping stainless steel screws.
- (2) Each signal section shall have a 2-inch diameter round hole in the top and bottom to accept a 1 ½ inch supporting pipe. After the sections are assembled, it shall be possible to pass a 1 inch cable through the head without damage or excessive labor.
- (3) The door latch shall be a variable pressure type, bolt and wing nut (AISI 300 series stainless steel) or approved equal.
- (4) The over-all height of each signal section of a “hand” and “walking person” symbolic icon signal face shall not be less than 14 inches.

E. Visors:

- (1) The visor shall be 10 inches long. The visor shall enclose the top and two sides of the lens. The visor shall be made of black polycarbonate resin having a thickness of no less than 0.070 inches, and shall be attached to the door with at least four screws (AISI 300 series stainless steel). The visor mounting shall be of sufficient strength and design to allow the head to be handled by the visor.
- (2) LED pedestrian signals shall be shipped with visors attached.

F. Exterior Finish:

- (1) LED pedestrian traffic signals shall be black in color. The inside surface of the visors shall be flat black. The characteristics of various signal components shall be an integral part of the material composition.
- (2) The color and finish of the signal parts shall be such that it will not require painting to maintain a pleasing and functional appearance. A scratch on any signal part shall not expose uncolored material.
- (3) Pedestrian signal mounting brackets, prior to painting, shall have all metal surfaces cleaned and pretreated before assembly to accept phosphate coating in accordance with federal specifications TT-C-490, Cleaning Methods and Pre-treatment of Ferrous Surfaces or Organic Coatings.
- (4) Semi-gloss or glossy black enamel shall be used to finish coat all other exterior surfaces of the fittings except stainless steel latch bolts and clips.

3. Electrical:

A. General: Minimum performance requirements for LED signals include:

- (1) The LED signal module shall operate from a 60 Hz line frequency and over a voltage range of 80-135 volts. A luminous intensity change of no more than $\pm 10\%$ shall be allowed over the voltage range.
- (2) The LED signal module shall operate over a temperature range of -40 to 165 degrees F (-40 to 74 degrees C).
- (3) Each LED signal module shall be provided with two color coded No. 18 A.W.G. minimum, 18-inch, 600v, jacketed wires, conforming to the National Electrical Code, rated for service at 225 degrees F (105 degrees C). The wire leads shall be provided with pre-insulated spade terminals for connection to existing traffic signal terminal blocks.
- (4) The LED signal module shall include voltage surge protection to withstand high-repetition noise transients and low-repetition, high-energy transients as stated in Section 2.1.6 of NEMA Standard TS-2.
- (5) The LED circuitry shall prevent flicker at less than 100 Hz over the voltage range specified in Section 5.2.1 of the LED Purchase Specifications.
- (6) The LED signal and associated on-board circuitry must meet Federal Communications Commission (FCC) Title 47, Sub Part B, Section 15 regulations concerning the emission of electronic noise.
- (7) Power factor shall be 90 degrees or greater, at nominal rated voltage, at 77 degrees F (25 degrees C), after 60 minutes of operation. Total harmonic distortion (THD) shall be less than 20 percent at rated voltage, at 77 degrees F (25 degrees C).
- (8) The LEDs shall be connected in series parallel strings. The failure of a single LED shall cause loss of light from only that LED. No loss of light output from the complete module assembly shall occur as a result of a single LED failure.
- (9) Each icon, "hand" and "walking person" shall have separate burn-in procedure.
- (10) Each icon, "hand" and "walking person", shall have separate light stabilization procedure.
- (11) When operating within the temperature range, the average luminance of the module shall not exceed twice the minimum luminance of the modules.

B. Power Consumption and Operational Range:

- (1) The LED pedestrian traffic signal shall consume no more than 10 watts at 12 VA, at 77 degrees F (25 degrees C).

4. Photometric Requirements:

- A. The minimum initial luminous intensity values for the LED traffic signal module shall be as defined in Section 4 of the LED Purchase Specifications.
- B. The LED pedestrian signal module shall meet the minimum intensity requirements while operating over the temperature range of -40 to 165 degrees F (-40 to 74 degrees C).
- C. The measured chromaticity coordinates of LED traffic signal modules shall conform to the requirements of Section 4 of the LED Purchase Specifications.
- D. Test data to verify pedestrian signal performance meeting Section 6 of the LED Purchase Specifications requirements shall be supplied by a certified independent test lab.

- 5. Warranty: All LED pedestrian signal modules supplied shall be warranted for 5 years from date of delivery against manufacturing defects. LED modules shall be performance warranted for 5 years per Section 6 of the LED Purchase Specification.

c. Measurement and Payment. The completed work as measured for the following contract item (pay item) includes furnishing and installing the LED pedestrian traffic signal modules, hardware, fittings, conduit, riser(s), grounding and ground rod(s), cable, and any other materials necessary to complete the work.

Contract Item (Pay Item)**Pay Unit**

TS, Pedestrian, _____ Way ____ Mtd (LED) Each